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Hawaii Agricultural Experiment Station,

HONOLULU.

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TOBACCO EXPERIMENTS IN HAMAKUA, HAWAII.

INTRODUCTION.

In the Autumn of 1903, a co-operative experiment was arranged under the joint auspices of the Territorial Board of Commissioners of Agriculture and Forestry and the Hawaii Agricultural Experiment Station, for the purpose of demonstrating the practicability of growing the best grades of cigar tobacco in Hawaii.

An examination of sites was made by Mr. F. E. Conter, a Special Agent, who, in the beginning, had charge of the work. Mr. Conter visited the Puna, Hilo, Hamakua and Kona Districts of the island of Hawaii and finally selected a small tract on the Louisson Brothers' Plantation on the lands of Pohakea, Hamakua. A lease of 2 1-2 acres of the land was secured in the name of the Secretary of Agriculture, Washington, D. C., at the nominal rental of Five Dollars per annum. Special privileges were granted by the owners of the land, who have assisted the enterprise in every way in their power. The land was new and uncultivated, so that a delay of some months ensued before the field could be made ready for planting. The first crop was transplanted to the experimental plots in March and April, 1904.

The experimental tobacco field was located in Hamakua because the physical character of the soil was right to produce a good quality of crop. The Pohakea Homestead lands were suitable, available and convenient. There are other areas in Puna, Kau and Kona on Hawaii and on each of the other Islands of the

group, but at the time this experiment was undertaken, the Pohakea tract was selected as the most convenient place in which to carry on field work.

WHERE CAN TOBACCO BE GROWN?

The determinant factors in the production of tobaccos of high grade and fine flavor are:

Soils of the proper physical texture.

A suitable climate.

Selected seed.

Clean cultivation, fertilization and the requisite skill in curing and fermenting the crop to produce a uniform quality of leaf.

TOBACCO SOILS.

The texture of a soil, that is, the ratio between clay, silt, fine and coarse sand, is held to have much to do with the type of the product. Good seed planted on unfavorable soils will not produce good tobacco. The texture governs the water-holding capacity of the soil, and this, in turn, controls, to some extent, the physiological changes within the growing plant; so that, eliminating other factors, the type of crop, which a given soil will produce, can be pre-determined, to some extent, merely by an examination of the soil.

The color of the cured leaf, whether light or dark, its thinness and elasticity, depend, apparently, almost absolutely on soil characteristics and its water-holding capacity.

SOME HAWAIIAN TOBACCO SOILS.

The soil on the Hamakua homesteads and on the Hamakua tract of land adapted to tobacco,—a belt extending from Paauhau to Hakalau at an elevation of from 1000 to 2500 feet—, is a sandy forest loam, very rich in humus and with a high nitrogen content. The color of the soil is a light brown becoming almost black when wet.

ANALYSIS OF POHAKEA SOIL.[1]

Physical Analysis	Per cent.	Chemical Analysis	Per cent.
Combined water and organic	35.935	Water	19.540
Fine gravel 1.—2. mm.	16.511	Organic and combined water	28.360
Coarse sand 1.—0.5 mm.	11.337	Insoluble	19.320
Medium sand 0.5—0.25 mm.	6.716	Fe_2O_3 } Iron and alu- Al_2O_3 } mina	28.797
Fine sand 0.25—0.1 mm.	14.002	Ca O. . lime	.300
Very fine sand 0.1—0.05 mm.	8.339	Mg. O magnesia	.631
Silt 0.05—0.005 mm.	5.848	$S O_3$ sulph. acid	.343
Clay 0.005—0.0001 "	.940	P_2O_5 phosphoric acid	.703
		K_2O potash	.077
		Nitrogen total	.728
		Humus "	12.470
		Humic nitrogen	.560
		Nitrogen % in humus	4.490

1 Analysis by Dr. Edmund C. Shorey.

It will be noted that although the "iron and alumina" content is high the percentage of clay is very low. The "fine gravel" and "coarse sand" are really reducable to "fine sand" and "very fine sand" if the soil is shaken in water for longer than the customary period previous to analysis. There is almost no true clay in this soil, and practically no true gravel or coarse sand.

The lime is present as a silicate and is too low in quantity to neutralize the acidity. The potash content is very low. Nevertheless a dressing of sulphate of potash applied to the experimental plots at the rate of 500 pounds per acre produced cigar leaf of exceptionally good burning qualities. The nitrogen although high is largely unavailable so that it will pay to use moderate amounts of nitrate on the crop. The phosphoric acid is presumably largely unavailable.

ANALYSIS OF KONA SOIL.

A tobacco soil above Kailua at an elevation of 600 feet compares very favorably with some of the best Sumatra soil:

Kailua, Kona Soil.1		Rimboen, Sumatra soil.2	
	Per cent.		Per cent.
Organic and combined water	30.82	Organic matter	23.41
Fine gravel	11.85	Gravel	.81
Coarse sand	13.25	Coarse sand	1.44
Medium sand	3.95	Medium sand	3.62
Fine sand	8.42	Fine sand	13.94
Very fine sand	28.25	Very fine sand	19.52
Silt	1.75	Silt	23.51
Clay	.85	Clay	2.72
Total nitrogen	.94		
Color of soil, light brown.			

1Analysis by Dr. Edmund C. Shorey.

2Bul. 5. Div Soils. U. S. Dept. Agric., Washington, D. C., 1896.

Hawaiian soils on cultivation rapidly disintegrate their coarser particles. The shotty particles technically classed as "fine gravel" and "coarse sand" when worked with a rubber pestle or rubbed between the fingers crush down to a fine powder. The ultimate soil grains are agglutinated in masses because of the exceptionally large percentage of organic matter in the soil.

The Kona district is undoubtedly better adapted to tobacco cultivation than Hamakua because of the protection from strong trade winds. But the tobacco soils of Hamakua and Kona are very similar in all their characteristics.

CLIMATE.

The influence of climate on the growing of tobacco is a potent factor. Cigar tobaccos, of good quality, are produced through a wide range in latitude. Proximity to the ocean has always been considered a deterrent influence.

Tobacco requires from 70 to 100 inches annual rainfall, from one-half to one-third of this during the growing season. Moderate temperatures, frequent showers or irrigation, to promote even, uninterrupted growth, neither too rapid nor too slow, constitute an important element in determining the suitability

of any district where soil sonditions are correct. Monotony of daily and seasonal temperatures are characteristic of Hawaii, so that the rainfall or the ability to irrigate the crop, when required, become of greater importance than any consideration of actual temperatures.

In the windward districts, protection from wind must be provided. This may be accomplished either by tenting the field with cotton cloth, as in Connecticut and Florida, or, permitting the larger ohia trees to remain when the land is cleared; or, in case tobacco is planted on lands cleared for cane or other "open-field" crops, by planting or constructing suitable windbreaks. In the leeward districts, the protection from wind may be neglected.

THE INFLUENCE OF GOOD SEED.

The necessity of procuring the best seed is a factor not to be neglected or minimized. The final test, as to the value of a crop of tobacco, does not come for at least a year after the seed is sown, and, in the case of the finer cigar wrapper and filler types, not for two or three years. Each year, more and more attention is being given to the selection of good seed. Tobacco seeds are extremely minute. An ounce, if every seed were good, would produce plants enough to plant several acres. It will be absolutely necessary for planters in Hawaii to save their own seed from the best individual plants of the best strains to the end, that a race of tobacco, adapted to local conditions, may be developed.

CULTIVATION AND FERTILIZERS.

Tobacco is a crop that re-pays the planter in proportion to the ratio of cultivation and attention that he gives it. It is not a crop that can be left to care for itself. Constant and painstaking supervision of every detail toward the making of the crop will well repay the cultivator. Tobacco is essentially a hoed crop. Weeds are plants growing out of place. Any plant, except tobacco, in a tobacco field is a weed and must be kept down. Cultivation and fertilizers must be used and applied for the purpose of maintaining an even, rapid growth, for there is no doubt that uniform rapidity of growth has its influence on the quality of the finished product. Light applications of nitrate of soda, at intervals during the growth of the plant, will do much to promote this required uniformity.

The curing of the ripe leaf and the fermentation of the cured article, are comparatively recent developments in the science of tobacco culture. These processes were formerly carried on by rule of thumb and the reasons for curing or fermenting were but little understood. It is now, however, generally recognized that curing and fermentation are controllable processes, which, when properly conducted, tend towards improvement of the quality and value of the finished article, the marketable tobacco.

If we are to produce tobacco on a commercial scale in Hawaii, the rules of experience which have been developed in Cuba, Sumatra or other tobacco-growing lands, must be modified and adapted to our own peculiar local soils, climate and conditions.

This Report is and can be only preliminary. The results of one year's experimenting indicate that we can grow fine cigar-leaf tobaccos of the Havana type, which can be classed in flavor, texture, aroma and burning qualities with the medium grades of tobacco imported from Cuba. Our volcanic soils are not comparable with the sandy soils of Florida or the limestone soils of Cuba, and yet, the fact remains that we have produced good tobacco and can probably do much better during the coming seasons, as a result of more experience and better equipment.

After comparison of our results with those obtained elsewhere in growing tobacco of fine quality, it is believed that uniformity of temperatures, with sufficient moisture during the growing season of the plant, have as much to do with the quality of tobacco as any other physical or climatic factor. If this be true, our remarkable monotony of temperatures and narrow variations, daily, monthly and seasonal, should make it possible to grow in Hawaii fine tobaccos which will, in time, be classed as distinct from those of any other land.

In the beginning, the market for Hawaiian grown tobaccos will be at home. It will be better in the beginning to develop and cater to the local demand.

SEED AND SEEDLINGS.

One of the main items for success in tobacco culture, is to have good, strong, healthy plants ready to transplant to the field at the proper time. Good *seed* is the first essential in their production, for without good stock to start with, one can hardly expect to obtain the best results. How to produce that kind of a plant is still question, whether by using a rich soil in seed boxes or beds

and procure a rapid growth of top upon a slender root, or, to use a poorer soil and develop more root growth and less leaf, depending upon the stronger root to give the plant a better start when set out in the field. It would appear that the stronger the root system, the better will be the results when the seedlings are transplanted.

An open seed-bed, as is used in other countries, would prove a failure in Hawaii. Insects are too numerous and the soil too full of humus to stand burning.

Two methods can be recommended. The first of these is *elevated* boxes, set about 20 inches from the ground on posts, the box level and projecting at least 6 inches outside the posts, 3 1-2 to 4 feet wide, 10 to 12 feet long and at least 6 inches deep. Fill full with good soil, sifted to remove sticks, trash and stones, the last inch being finer, so that the seed, which is very small, may come in closer contact with the soil but not be covered too deeply. Add a pound or two of air-slaked lime and mix well with the last 2 inches of top soil filled into the boxes or beds.

Good soil can always be distinguished by its texture. If it is soft, moist, not too cold and has a velvety feel, it is good, whereas, a coarse, hard, dry soil, feeling like small peas or pebbles, will not hold moisture, it being too open and porous. Soil rich in humus is sour and, in it, plants do not do well on this account. The lime added to the top soil in the seed-bed corrects this acidity. It is often a good plan to water the seed-bed with lime water, even after the plants are up, but the best is to mix the lime in the top soil.

The seed-boxes, when the seeds show up, should be covered with a gable-roofed frame, covered with cheese cloth or light, open cotton. This cover retains the moisture, maintains a more nearly uniform temperature, and wards off insects.

The other method is to build a large cloth house, with gable roof and in it, arrange the beds so as to get around among them, The elevated boxes, for a few plants, are the easiest to make and care for. In an excessively rainy period, the boxes do not drain off the water as well as the beds and become cold and soggy. For growing a large number of plants, the seed house is to be preferred.

All seed boxes and beds should be sterilized, especially to kill insects and their eggs. An easy way to do this is to use from 10 to 20 gallons of boiling water, applied as evenly and quickly

as possible and cover with some kind of a blanket to retain the heat. A pair of saddle blankets answer the purpose nicely.

After the seed-beds become cold, they are ready for the seed, and if the top has become packed, it should be loosened and made fine.

Tobacco seed is exceedingly small, an ounce containing about 380,000 seeds, of which, at best, only about 50 per cent. will germinate. One pod produces fully 5000 seeds and one plant is capable of furnishing seed enough to plant 250 acres, if all were to grow. One heaping tablespoonful of seed will sow 100 square yards of seed-bed and furnish plants to set from 4 to 5 acres, with 10,000 plants per acre, of cigar tobacco. Mix the right quantity of seed with a quart or so of dry, sifted ashes. The ashes show where the seed has or has not been sown on the surface of the bed.

The seed-box or bed, after sowing, should be watered, using a fine rose watering-pot, so as to moisten the soil and also to pack it around the seed, but only enough water should be used to give the desired result.

Cover the seed-boxes or beds with open burlap (old grain bags, cut open, do well for this purpose), until the young plants appear, then the boxes are ready for their movable gable-roofed covers. All covers for plants, after they are up, should be so constructed that the roof partially turns the water, or else it drips through in large drops, which soon kill the tender leaves of the plant by pounding them against the ground. All flat covers should be avoided, for the same reason, unless the cover comes in direct contact with the surface of the ground and, even then, a very heavy rain makes a crust on the top of the soil.

Tobacco seed should be sown thinly, so the plants have room to grow; each plant should have at least one square inch of surface to make a sturdy plant. Seed-beds should, at all times, be fairly moist and never be allowed to become dry or to show dryness on the surface. The seed is small and is only planted on the surface. Good seed should germinate in from 12 to 15 days. In from six to eight weeks, the more hardy plants will be ready for the field and the others will follow in quick succession, until the bed is exhausted of all desirable plants.

Young plants should be allowed considerable sunshine to harden them before transplanting.

Every tobacco grower should save his own seed, and, in its selection, care should be taken to save seed only from such plants

as fill all the requirements that are exacted by the trade in the finished leaf.

In a field of growing tobacco, many types may be observed. The best should be selected for seed. By protecting the seed heads or keeping all other plants well topped, cross fertilization may be avoided.

Seed plants should have the small upper leaves and all the sprouting seed branches and suckers removed and seed only saved from the center head. All the large leaves should remain on the plant until seed is mature, when the pod turns brown in color.

PLOWING AND TRANSPLANTING.

The land selected for a tobacco field should be such as can be plowed both ways. It should be sheltered from the high trade winds that sometimes blow with great force. Small square plots, of from 2 to 5 acres each, would form good fields for a small planter, especially if surrounded by the forest. It is well to plow the land some little time in advance of the planting.

Tobacco being a tap-rooted plant, in some instances sending its roots down to a depth of 2 feet or more, requires that tillage shall be deep in preparing the land to receive the young plants. The soil should be plowed to a depth of at least 12 inches. The work must be done in such a manner that the sub-soil is not brought to the surface. Have the soil fine and loose but leave the sterile, acid sub-soil underneath where nature placed it. Put the soil in good, mellow condition, as it pays to do so for any crop.

As soon as the land is plowed and harrowed, the field should be poisoned to kill pokos, army worms, Japanese beetles and the various pests usually abundant in newly turned land. There are two remedies which are of about equal value. Sow one or the other of the following broadcast over the newly plowed land:

Arsenicated Horse-manure. To 40 pounds of dried, fresh horse manure, as free from straw as possible, add 6 to 8 ounces Paris Green mixed with 5 pounds of common salt. Stir until the salt and Paris Green are thoroughly incorporated in every part of the manure. This amount is sufficient for one acre.

Poisoned bran. To 2 pecks of bran or coarse cornmeal, add 4 ounces Paris Green or 8 ounces disparene and 2 quarts of molasses

or honey or 5 pounds coarse sugar. If sugar is used, moisten the bran with water. Stir and mix thoroughly and scatter over the field.

Poisoned horse-manure is safer than poisoned bran and somewhat cheaper. Pokos and army worms like it fully as well as the sweetened bran and cattle, chickens and other domestic animals are less liable to be poisoned through eating it. The Japanese beetle seems to prefer the poisoned bran.

The field being prepared and the plants ready, they can be set out at any time of the year when the soil is in a moist condition and the sky is clouded. Plant only good, strong, healthy plants in the field. It is poor economy to set a sickly plant anywhere and give it care and cultivation, with but little chance for a return from it for the time and labor expended.

It can hardly be expected, and especially in Hawaii, that every seed will grow and produce an ideal plant. Such has not been our experience. It seems to be a characteristic of tropical countries, and, to this Hawaii is no exception, that cultivated plants show marked individual variation in their growth. Some plants, even of types that show unformity when grown in cooler lands, when grown in hot countries break up into a number of forms. There must be enough good plants to reset in the places of those that fail to grow or vary from the type.

The tap-root of a tobacco plant is its anchor. In planting, it should be kept as straight as possible. The growth and success of the plant depends upon this being carefully looked after. Our experience has been that eight out of ten plants that failed to make a good growth could be traced to a deformed tap-root or careless transplanting.

In taking up young plants from seed-beds or boxes, use a pointed stick to run under the plants wanted, and, with a prying and twisting motion, this plant is so loosened that, taking it by the tips of the top leaves, it can be lifted from the soil with most of its roots intact. Do not take hold of a small plant at the growing bud, for it will be bruised, no matter how lightly handled. If the plants are large, they may be handled at the base of the stalk far better than by the leaves when planting out in the field.

Pack the plants carefully in a broad, shallow basket or tray, provided with a handle and keep covered from the air and the sun. If the field is near, do not lift too many at one time. Do not place any of the plants in water, as it causes all lateral roots

to cling to the tap-root, from which they can not easily be separated, thus causing the plant to be poorly set. A little loose, damp earth, sprinkled among the roots of the plants and the tops slightly wet and covered, prepares the plants to stand a longer journey. Properly packed, they can be set next day with good results or can be transported to some distance. It often saves time to set a few extra plants now and then through the field, between the regular rows, to be used later to fill vacancies that may occur. Quite large plants can be moved if a little soil is left around the roots.

Sometimes it is advisable to set small plants from seed-beds or boxes to a nursery until they attain a larger growth, if not enough seed boxes or beds have been provided. Another good reason for doing this is that after a good many plants are removed, the remainder are loosened and disturbed.

If the sun is shining when the seedlings are transplanted, the young plants need some shade until they start. Ti leaves make a good shade. Stick the stem end into the ground and bend it over the young tobacco plant and fasten the other end with a handful of soil laid upon it.

Take the plants from the seed-beds with all the roots possible. Do not pull them up and break the lateral roots, but loosen the soil well and take up carefully. If the tap-root is too long, pinch it off some, but be sure to plant it straight. Set the plants well into the ground. Set large plants with the hand and have the soil so loosened up that the end of the fingers do not come in contact with the *hard sub-soil* in scooping out a place to set the plant, then holding the plant in the center of the hole thus made, supporting any lateral roots with the fingers, firm the bottom of the tap-root with soil up to the lateral roots, then spread these out and place fine soil upon them, fill up and firm the top with the hands or with the feet.

In Hamakua, tobacco can be set at any time and will grow, but it will grow better and faster from February to September (warm weather), although, if set in September and October, if the ground is wet, it will make enough growth to mature a crop during the cold weather.

It pays to take considerable pains to get good stocky plants and have them well set. A full stand of seedlings of uniform age and vitality is the first requisite towards success in growing tobacco.

If the acreage is large enough to warrant the outlay, transplanting machinery may be employed. With three men and a good team, from two to four acres of tobacco can be transplanted in one day. These machines set the plant, water it and pack the dirt around it, and, when running in proper shape, do the work more uniformly than a gang of laborers.

Young plants can also be set with a flat, round-pointed dibble. This instrument leaves a deep, narrow opening in the soil, allowing room for the lateral roots to stand out straight and the earth is firmed up against the plant. The roots are then in a good position and not cramped up in a small, round hole. If water is used during planting, the hole left by the dibble in firming the plant, is the proper place to apply the water.

Care should always be used in handling young tobacco plants, as the leaves and shoots are very brittle and tender and break easily. Tobacco should be planted on slightly raised ridges, some 3 or 4 inches higher than the surrounding ground, as it facilitates drainage, places the plants in a more decided position and less liable to injury through cultivation.

The distance between the plants in the row and the width of the rows is governed by the kind of tobacco planted and the use to which the finished leaf is to be put, whether wrapper or filler.

Planted close in the row and the rows near each other, the tobacco grows tall, with short, narrow, thin leaves, of a poor body, because they do not get enough sunshine to properly ripen. On the other hand, plants set far apart in the row and a greater distance between the rows, giving more room for the plant to expand, produce the other extreme, a long, wide, thick leaf of heavy body, coarse veins and a woodiness in the cured leaf that is undesirable.

No cigar tobacco should be set less than 15 inches apart in the row, and not less than 3 feet between the rows. Room to cultivate must be left so that the laborers will not break and tear the leaves when working between the rows. But the right distance to plant must be determined by each planter to suit the type of tobacco grown and the character of the soil.

In Hamakua, the average cigar tobaccos, such as the Cuban, Sumatra, Connecticut seed leaf and Zimmer Spanish, do well 15 inches in the row and 3 feet 5 inches between rows. An acre, set at this distance, contains about 10,000 plants.

The manufacturing tobaccos producing a larger leaf require

more room each way and should be set 2 feet 4 inches apart in rows 4 feet apart.

The tap-root of a good tobacco plant will go down over 2 feet and its laterals run 2 and 3 feet each side of the stalk.

The lateral or feeding roots run just under the surface of the ground so that cultivation must not be deep enough to disturb them, therefore the more need of a clean field at the start. A clean field is much easier to take care of than a weedy one. A garden rake, lightly run over the surface of the ground, disturbs the crust formed by rain, stopping evaporation and killing sprouting weed seeds. The field is only occupied by the tobacco 3 to 4 months for each crop and should be kept clean for that time. Plants show their appreciation of good care and it pays to attend to their wants.

Having no frosts in Hawaii, throughout the belt of land that can be planted to tobacco, any backward plant can be left to come to maturity and its leaf finally secured, but such plants must not be allowed to flower or produce seed.

TOPPING AND SUCKERING.

In about seven to eight weeks after setting in the field, the plant will send up a head or seed cluster, which should be removed in all cases before any of the flowers open.

Topping must not be neglected, as the pollen and falling petals adhere to the green, gummy leaves, causing them to spot in this climate and become worthless.

Sometimes before topping, but generally after, suckers will start from where the leaf joins the stalk. These must be removed, because they take nutriment from the plant that should go to the leaves, it being leaf development that is wanted.

After the main crop is harvested, a sucker crop may be raised. It is doubtful if it will pay in Hawaii, as it is a difficult matter to get the sucker to grow from the bottom part of the plant, but if all the upper suckers are kept off, a bottom sucker will usually start. After all the leaves on the plant are harvested, the stalk should be cut just above the sucker. If this sucker is not allowed to grow before the plant is cut down, it will not start in this climate, the old plant dying down into the root.

In topping, sometimes a backward plant may be made to increase its yield of leaf from 10 to 20 per cent., if topped a little lower than usual and a sucker allowed to grow from the top of

the plant and that, in turn, topped and suckered like the original plant. In topping, cut below the third leaf from the seed bud.

HARVESTING AND CURING.

Between the time of planting and harvesting, a tobacco barn must be provided large enough to care for the entire crop. This structure should be of lumber rather than galvanized iron, with shingle roof, hinged frieze, or gable-ventilators and the sides provided with vertical ventilators extending from sill to plate the idea being to secure complete control of temperature and air draughts within the building during the curing process. The side walls should be of 1"x12" N. W., with the cracks battened. Windows are not required, as the ventilators may be opened for light during the process of filling the barn with green leaf. The inside arrangement should be such that the tobacco leaves, fastened on four foot laths, can be hung in tiers from top to bottom of the shed, so as to fill the whole space. The larger the barn, the more readily can the air temperature within it be controlled. A tobacco barn, properly constructed, should last for twenty years. In Hamakua, at the elevation where our tobacco experiment is being conducted, a stove must be provided to heat the air and control moisture, because of the frequent periods of fog and cloudy weather. This stove is placed outside of the shed with the pipe or flue passing either across through the house, from side to side, or, inside a large barn, around two or more walls.

In from 3 to 4 weeks after topping, some of the leaves will be ripe. The lower ones ripen first and if not removed, they wither, turn yellow, dry up at the point, get spotted in patches and then fall off, a total loss of leaf, as the tobacco is then fit for nothing.

There are two methods in use in harvesting tobacco. For high grade cigar leaf, priming is the one to employ. Each leaf is cut from the plant as it ripens, and, as three or four leaves are ripe at about the same time, it is not so much work as one would think.

The primed leaves are placed in shallow trays or baskets and taken to the curing house. The leaves should be carefully handled to avoid bruising and breaking. It is a great saving of room in the curing house, if at this time, the leaves are assorted according to length.

Tobacco does not cure well if strung, say a 20 inch leaf that is 12 inches wide next to a 12 inch leaf that is 6 inches wide. The wide, long leaf will, in curing, roll over the small one and cover

it, so it does not dry properly, but has every chance to mold and also cause the outside leaf to mold.

Room is also gained in the house, as the racks can be so placed to accommodate the different lengths without waste of space. It does not require 24 inches of space in which to hang a 12 inch leaf.

Assorting is more quickly done in the green state, as far as length and width are concerned, than when the tobacco is cured.

In curing, the leaves shrink one inch in every twelve inches of length and in the same proportion for the width. The green leaves, sorted to length, are strung with a sail needle upon cotton twine, face to face, and back to back, about one inch apart. The string is knotted at each end and the ends are slipped into a cut in each end of a 4 foot lath. The laths are then carried and hung in tiers upon the racks within the barn.

Patented tobacco poles, consisting of laths with sharp-pointed 12 inch wires, fixed six inches apart and extending half their length on each side of the lath, are much used in some mainland tobacco districts. The green leaves are strung through their stems on these wires, 4 to 6 leaves on each end of the wire. The leaves should not touch each other. As they wilt, the poles may be shoved along closer together, thus greatly economizing space.

As soon as the house is filled with green leaf, close all the ventilators, and, if the weather is rainy or foggy, apply a gentle heat. If hot and dry, the artificial heat is not required. No exact rule of procedure can be laid down, but the temperature and ventilation in the curing barn must be so regulated as to cause a gradual yellowing of the leaf. The more this process of gradual death of the living cells of the leaf can be prolonged, without inducing the development of molds, rot and pole burn, the better will be the quality of the finished article. Sudden changes of temperature are injurious to the leaf.

All living green plants contain within their cells various unstable chemical compounds known as "enzymes." The physiological function of these "enzymes" is but little understood, but it is known that they increase in amount when the vitality of the plant is weakened by disease. The function of the leaves of plants is to elaborate food to the end that the plants may complete their full life-cycle, put forth flowers and ripen seeds to reproduce the species.

In the artificial cultivation of tobacco, the natural life-cycle

of the plant is disturbed and interfered with through continuous topping and suckering or pinching off of all flower buds. This causes what might be called a diseased condition in the leaves. Instead of being able to live as millions of generations of tobacco plants have lived before man took to cultivating this crop, the plant is forced, whenever it gets ready to flower and reproduce itself, to turn back and again store up the necessary supplies of food in the leaves, always having seed production as the ultimate object. In this artificially diseased state, the enzymes within the living cells increase enormously and this is what primarily constitutes the "ripening process" of tobacco leaves. A plant cell, which is being gradually murdered, acquires a comparatively large stock of enzymes. On the contrary, where death is rapid there is but little development of these compounds. It is through the oxidation and chemical breaking down of these enzymes that the curing of a ripe tobacco leaf is effected. In a green leaf that is cut or broken from its mother-plant, the enzymes present are rendered inert if it is quickly dried so that death of the plant cells is rapid. The heat, light and humidity in a tobacco barn must be controlled and manipulated so as to cause the death of the green cells of the leaf by gradual starvation. As the green color fades out of a properly cured leaf, it is succeeded by the characteristic rich, mellow, tobacco brown. When the veins and midrib of the leaf have lost their green color, the tobacco is cured. In Hamakua, the curing process requires from two to four weeks.

The determination of the proper time to harvest tobacco leaves is a matter of judgment and experience. Leaves that are under-ripe cure greenish, thin, papery and brittle. Those over-ripe become harsh, thick and of uneven color. A ripe leaf cures gummy, pliable, elastic and of an even color.

Each kind of tobacco has its special characteristics and must be treated accordingly. Cigar tobaccos require slower barn curing and more careful manipulation during the whole period of growth, curing and fermentation than do the cheaper grades of manufacturing and export tobaccos.

FERMENTATION.

The fermentation or bulking house should be constructed of T and G or other matched lumber or of 1"x12" N. W., battened, in order to have the room where the fermenting is done air-tight.

Controllable frieze ventilators and windows must be provided. The sills should rest on or in the ground, leaving a dirt floor.

As soon as the tobacco in the barn is cured and has been tied into hands, an operation that must be made while the tobacco is moist and pliable, the hands are packed in cases and taken at once to the fermenting house. The tobacco, when cured, must not be handled when it is dry, else it will crumble and be broken, thus destroying the value of such leaves as are suitable for wrapper.

In the fermenting house, platforms raised about 6 inches from the floor, 12 feet long by 5 feet wide and with boarded ends 7 feet high, have been built. The bottom and ends of the platform are lined with heavy paper.

The hands of tobacco, fresh from the curing house, are placed side by side, butt out, even with the edge of the platform, tip towards center. Another row is then laid, overlapping, tip towards center and so on until the floor of the platform is covered. Layers are built on top of this in the same manner until the pile is from 5 to 7 feet high. A cotton blanket is spread over the pile and this covered with rubber blankets or tarpaulins.

If the tobacco is sufficiently moist and pliable when placed in bulk, fermentation begins at once. A platform, 5x12 feet, will accommodate 5000 to 6000 pounds of leaf. A more satisfactory ferment will be secured using this quantity than with a smaller amount.

The leaves should have from 25 to 30% of moisture when placed in bulk. If too dry, the amount can be increased by wetting down the floor and walls of the house with hot water, or, by leading live steam into the room during the time that the bulk is being filled, as cured tobacco leaves very readily absorb moisture from the air. After the bulk is finished, the temperature of the room should be kept rather high, the ventilators being occasionally opened to permit escape of the ammonia which is generated in volume. If the tobacco was sufficiently moist, there will be a daily rise in temperature or from 5° to 8° F.

"In large establishments the temperature and humidity of the room can be thoroughly regulated to secure uniform progress of the fermentation. This is done by steam pipes to warm the room, in which there are vents for the escape of steam when it is desired to make the atmosphere more moist. The temperature of the room is kept quite high, and the vapor from the bulk which is being worked over is very pun-

gent and almost overpowering. There is a very strong odor of ammonia, which makes it difficult to breathe.

The bulk is watched very closely, and as the temperature rises it is torn down, each hand of tobacco is taken up and shaken thoroughly to dry it a little, to cool it slightly, and to open the leaves so that they will not stick together. Before the sweat is completed the bulk is pulled down and built up eight or ten times, according to the condition of the tobacco. It is impossible, even for an expert curer, to give explicit directions as to when the bulk should be turned, as it depends entirely upon the condition of the tobacco and the temperature it attains, and these must be determined by the operator.

The temperature must rise gradually, and if it is found to be rising too rapidly the bulk is torn down and a fresh one built up. Sometimes the bulk is not up over twenty-four hours before it is torn down again and built up afresh. If the tobacco is in high case—that is, quite moist—the bulks have to be turned over frequently in order to prevent too rapid action and to shake out the leaves which would otherwise stick together. If a bulk, as seldom happens, should dry out, it is turned over and mixed with a bulk which is in high case. The tobacco should never be sprinkled in this stage of the process to bring it into case.

The temperature of the pile is allowed to rise gradually until it occasionally reaches 140° F. The fermentation is then at its highest. From this point the temperature subsides until the fermentation is complete and the bulk attains the normal temperature of the room. This maximum temperature must not be reached too quickly, and it must be managed differently with the different tobaccos. The fermentation must be carefully controlled and not allowed to go too far with the wrapper leaf. With the filler, the further it goes and the more intense the action the stronger and finer will the tobacco be for its purpose, if the work is judiciously done. As a matter of fact, it is not unusual to resweat the filler leaf to bring out the strong, rich properties which it is desired to develop. As the fermentation does not extend to the bottom of the pile, it is customary to put 8 or 10 inches of trash, which has already been sweated, on the bottom.

After the sweat the tobacco is brought into proper case and is then very carefully sorted. The wrapper leaf is sorted into four grades of light wrappers and four grades of dark wrappes, according to the length of the leaves. These are placed in small boxes on either side of the operator, and when a box is full the leaves are taken out and the Cuban tobacco is put up into "carottes" (cylindrical rolls). The carottes are made up into bales similar in every way to the Cuban package, the wrappings being imported from Cuba for the purpose.

The filler leaves are frequently resweated and are usually petuned, a process which makes them very much heavier, darker, and stronger. The petuning is either done by spraying, which is the best way, or by dipping the tobacco. The essential part of the petuning liquid is a thick infusion of tobacco stems of the finest quality obtainable. To this is added molasses, cider, Jamaica rum, or sour wine. Frequently other

matters are put into the petuning liquid, according to the taste or fancy of the operator, to add quality to the leaf. This is a secret of the Cuban method, and the only part of the process which they are unwilling to divulge.

When the petuning is done by dipping the tobacco, each hand is dipped separately and is then thoroughly shaken, after which it must be bulked down to draw—that is, until the moisture has become thoroughly absorbed and evenly distributed through the leaves. Otherwise they would be apt to spot and change color. The wrappers are never treated in this way, as it is not desirable that they should have the properties of a good filler.

After the bales have been made up they are put into a warehouse in piles, not over three or four bales high, and should be kept at a moderately uniform and rather cool temperature at least two years, in order that the tobacco shall age, before it is suitable for making up into cigars. There seems to be no particular change that goes on, at least no noticeable outward change, as in the case of fermentation, but the tobacco loses the harshness that is always noticeable in fresh tobacco and becomes mellow, as wines and liquors do by standing. When properly put up it will keep almost indefinitely in the bale, and the longer it is left to age the better it becomes.

There is no doubt that tobacco can be handled much better, as well as more economically, in large than in small quantities. The fermentation is much more uniform in large bulks than in small. If there are several bulks they can, if necessary, be mixed to insure the proper conditions. The different kinds of tobacco need to be treated differently, and this is only possible in case of a large quantity, where the selections will amount to enough to handle. With a large quantity of tobacco, also, it is possible to grade more carefully and more closely, and lastly, it is always essential to have a large supply of tobacco of uniform quality in order that manufacturers may maintain any particular line of goods they may desire. For these reasons the farmers usually sell their crops from the field or from the barn to the larger producers or companies who maintain curing houses."[1]

In Hawaii, the period of fermentation lasts 60 to 90 days. Five pounds of green leaf produce about one pound of finished tobacco.

THE TOBACCO FARM IN HAMAKUA.

The crop planted during March and April, 1904, was the first systematic and scientific attempt to grow tobacco in Hawaii.

An acre was covered with an open wove cotton cloth, "Ariel Tenting Cloth," put upon plates and posts, forming a flat roof

[1]U. S. Dept. Agric. Farmers Bul. No. 60, second revised edition; Washington, D. C., 1902, sent free on application to the Secretary of Agriculture.

about 9 feet above the ground; the sides were also covered with the same kind of cloth, making a tight enclosure.

This covered plot, with some land adjoining, about one and one-fourth acres in all, was planted as follows:

Sumatra, Florida	71.13	per cent
" Long Stem	2.34	" "
Cuban, Florida	11.73	" "
" Vuelta Abajo	2.84	" "
Connecticut Broad Leaf	2.77	" "
" Seed	2.05	" "
Zimmer Spanish	2.98	" "
Virginia Dark Leaf	.64	" "
White Burley	3.20	" "
Japanese	.32	" "
	100.00	

A good many plants under the cloth shelter were killed by the drip from the seams, wires and plates of the structure. This first year's work demonstrated quite clearly that tenting tobacco is not a success in Hawaii, at least in regions of high rainfall.

The following field notes may prove of interest and value:

Plot A. Sumatra.

One thousand plants produced 19,309 leaves, weighing green, 684 pounds or 137 pounds of finished tobacco.

2,230	leaves,	less	than	12	inches	long,	weighed	41	lbs.	13 oz.
1,711	"	"		12	"	"	"	43	"	"
1,900	"	"		13	"	"	"	54	"	9 "
2,209	"	"		14	"	"	"	72	"	6 "
2,152	"	"		16	"	"	"	80	"	6 "
2,283	"	"		16	"	"	"	95	"	5 "
1,895	leaves,	17	inches	long,	weighed	91	lbs.	3	oz.	
1,578	"	18	"	"	"	84	"	4	"	
1,015	"	19	"	"	"	58	"	12	"	
605	"	20	"	"	"	42	"	7	"	
243	"	21	"	"	"	15	"	8	"	
178	"	22	"	"	"	4	"	7	"	
38	"	23	"	"	"	—	"	—	"	

1,273 waste and torn leaves weighed 35 lbs.

The average per plant was 19.3 leaves, weighing 11.5 oz. and the estimated yield per acre containing 9,680 plants was 6,332 lbs., green leaf, which would make 1,260 lbs. finished tobacco.

One plant on "Plot A." bore leaves 26 inches long by 15 inches wide and yielded 30 ounces of green leaf. Seed was saved from it.

The average weight of the stalk, after harvesting the leaves, is about 10 ounces. Sumatra tobacco averages 8 to 9 feet in height and tops at about 7 feet.

Plot B. Sumatra.

This tobacco was not cut until over-ripe, because of insufficient provision for handling the crop. Many of the lower leaves had dropped off. 1,024 plants yielded 13,228 leaves, weighing 413 lbs. 7 ounces green, the average per plant being 13 leaves, weighing 65 ounces. The average loss, through delay in harvesting, amounted to 3 lbs. 6 oz. per plant.

Plot C. Sumatra.

1,079 plants yielded 18,044 leaves, only a portion of which were weighed or measured as the crop was far past its prime.

Plot D. Section 3. Florida Cuban—492 plants.

This tobacco grows 5 to 7 feet in height and tops at 4 1-2 to 5 1-2 feet. 4,025 leaves were harvested as follows:

525	leaves,	less	than	12	inches	long,	weighed	9	lbs.	11 oz.
400	"	"		12	"	"	"	9	"	13 "
563	"	"		13	"	"	"	15	"	1 "
563	"	"		14	"	"	"	20	"	9 "
526	"	"		15	"	"	"	22	"	5 "
505	"	"		16	"	"	"	24	"	12 "
369	"	"		17	"	"	"	21	"	1 "
300	"	"		18	"	"	"	19	"	3 "
200	"	"		19	"	"	"	14	"	7 "
100	"	"		20	"	"	"	8	"	5 "
50	"	"		21	"	"	"	4	"	4 "
							Total....	169	"	7 "

Each plant yielded on an average 10.6 leaves, weighing green, 6.8 ounces. Florida Cuban tobacco will stand planting 15 inches apart, in rows 3 feet apart or at the rate of 11,500 plants to the acre. The estimated yield per acre on the basis of the yield obtained is 4,870 lbs. green leaf or 970 lbs. finished tobacco.

Plot E. Section 3. Vuelta Abajo, Cuban.

This is a low growing tobacco averaging about 4 1-2 feet and topping at 3 to 3 1-2 feet. 210 plants yielded 1,500 leaves.

100	leaves,	less	than	12	inches	long,	weighed	1 lb.	10 oz.
210	"	"		12	"	"	"	4 "	7 "
240	"	"		13	"	"	"	5 "	11 "
303	"	"		14	"	"	"	8 "	11 "
297	"	"		15	"	"	"	9 "	10 "
200	"	"		16	"	"	"	7 "	11 "
100	"	"		17	"	"	"	4 "	9 "
50	"	"		18	"	"	"	2 "	8 "
							Total....	44 "	13 "

The average per plant was 7.2 leaves, weighing green 3.4 ounces. This tobacco would stand planting 12 inches apart, in rows 3 feet apart or at the rate of 14,500 plants per acre. The estimated yield per acre is 3,080 pounds of green leaf or 616 pounds finished tobacco.

Plot E. Section 1. Connecticut Broad Leaf.

This tobacco grows 4 to 6 feet tall and tops on an average at 3 feet 8 inches. Some of the leaves were 37 inches long by 16 wide. 149 plants bore 2,257 leaves as follows:

294	leaves,	15	to	18	inches	long, weighed	8 lbs.	2 oz.
407	"	18	"	21	"	" "	34 "	14 "
523	"	21	"	24	"	" "	32 "	8 "
367	"	24	"	27	"	" "	33 "	1 "
280	"	27	"	30	"	" "	3 "	0 "
21	"							
360	"	waste and over-ripe				"	18 "	1 "
						Total....	149 "	9 "

The average per plant was 15.1 leaves, weighing 1 pound. This tobacco is planted 18 inches apart, in rows 42 inches apart. It should have been spaced wider, at least 30 inches in the row and 48 inches between rows. Our yield was at the rate of 7,820 pounds of green leaf or 1,560 pounds of finished tobacco. Connecticut Broad Leaf is difficult to cure because of the extraordinary thickness of the midrib and lateral veins. None of the other varieties of tobacco grown were weighed or measured.

Connecticut Seed Leaf cured lighter than any of the other tobaccos and gave a thin, light leaf, fit for wrapper.

In the curing shed, this molded very badly. White Burley would not cure or even dry without molding. It will require a high heat to cure. It is a pipe tobacco and is also, to some extent, used as a filler in cheap, domestic cigars.

Japan Tobacco is about the same as the Broad Leaf, a wide

leaf, not quite so long but with a large midrib. It is a pipe or cigarette tobacco.

Zimmer Spanish cured very dark, harsh, dry and brittle and did not absorb much moisture even in a rainy time. It is used for filler in the cheaper grades of domestic cigars.

The following tables show the leaf measurements in inches of five good Sumatra plants and the height and number of leaves of plants of some other varieties.

SOME GOOD TOBACCO PLANTS.

Sumatra.

Seed Plant	No. 1	No. 6	No. 9	No. 15	No. 17
Topped at	7′ 9″	7′ 3″	7′ 7″	7′ 9″	7′
No. of Leaves	23	27	22	25	22
Weight of Leaf	1lb. 13oz.	2lb.	1lb. 14oz.	1lb. 9oz.	1lb. 9oz.
First Leaf-Bottom	7x16	7½x14	7½x17½	7x15	7½x16½
2nd. "	8x16	6x13½	7½x18	8½x16	7½x17
3rd. "	8½x18½	8x15½	8½x19	8½x16	8½x18½
4th. "	9½x18½	8x15½	9x19	8½x17	9½x19
5th. "	9½x19	8x16½	9x21	8x16	10x19
6th. "	10x20	9x18	10x20½	9x18	10x19½
7th. "	10x20	9x17½	10½x23	9x17½	11x22
8th. "	10½x21½	9x16½	10½x22	8½x17	11x21½
9th. "	12x23	10x18	10½x22	9x18	12½x21
10th. "	13x23½	10½x18	10½x24	9x18	11½x22½
11th. "	14x24	11x18½	12¼x24½	9x19½	12x22
12th. "	13½x24	10x18	13x24½	10x20	12½x23½
13th. "	13½x24	10x18	12½x24	10x20	12½x23
14th. "	14x24½	11x19	13x25	11x19½	12½x23½
15th. "	13x24	10x18	13x26	11x20	13x23
16th. "	14x23½	9½x17	13x24	11x20½	11½x22
17th. "	14x23	9½x18	13½x25	11x21	11½x22
18th. "	12½x22	10x17	13½x24	11x19½	11½x20
19th. "	11½x22	11x17½	11½x21	11½x20½	11x19½
20th. "	12½x20	10x17	11½x20	10½x20	10½x16
21st. "	10½x15	10x17	9x15	9½x19	7½x13
22nd. "	10x14	10x17	6x12	10½x18½	4½x9
23rd. "	7x10	10x17	.....	9½x16	.....
24th. "	.....	10½x17	.....	9x15	.....
25th. "	.....	9½x17	.....	7x11½	.....
26th. "	.....	8x14	.....	.....	.....
27th. Top	.....	8x12	.....	.....	.....

Variety	Height	No. of leaves	Height	No. of leaves	Height	No. of leaves	Height	No. of leaves
Conn. Seed Leaf	7′ 9″	27	.8′	27	7′ 9″	28	7′ 9″	26
" Broad "	6′	21	6′ 3″	20	7′	19	....	....
Cuban Florida	6′ 2″	18	7′	21	6′ 3″	20	5′ 9″	20
Cuban Vuelta	5′ 9″	20	5′ 8″	18	5′ 9″	19	....	....
Zimmer Spanish	5′ 3″	26	....	...	....	...	....	....
White Burley	5′ 6″	21	....	...	....	...	....	....

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